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Estimating Gross Value Added (GVA) across multiple scales: theorical approach and empirical validation

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ABSTRACT

This paper presents an application of the Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) approach to the estimation of quantities of Gross Value Added (GVA) referring to economic entities defined at different scales of study. The method first estimates benchmark values of the pace of GVA generation per hour of labour across economic sectors. These values are estimated as intensive variables –e.g. €/hour– by dividing the various sectorial GVA of the country (expressed in € per year) by the hours of paid work in that same sector per year. This assessment is obtained using data referring to national statistics (top down information referring to the national level). Then, the approach uses bottom-up information (the number of hours of paid work in the various economic sectors of an economic entity –e.g. a city or a province– operating within the country) to estimate the amount of GVA produced by that entity. This estimate is obtained by multiplying the number of hours of work in each sector in the economic entity by the benchmark value of GVA generation per hour of work of that particular sector (national average). This method is applied and tested on two different socio-economic systems: (i) Catalonia (considered level n) and Barcelona (considered level n-1); and (ii) the region of Lima (considered level n) and Lima Metropolitan Area (considered level n-1). In both cases, the GVA per year of the local economic entity –Barcelona and Lima Metropolitan Area – is estimated and the resulting value is compared with GVA data provided by statistical offices. The empirical analysis seems to validate the approach, even though the case of Lima Metropolitan Area indicates a need for additional care when dealing with the estimate of GVA in primary sectors (agriculture and mining).

Keywords: *Multi-Scale Analysis, Gross Value Added assessment, MuSIASEM*

1. Introduction

1.1 The challenge of multi-scale analysis

Quantitative analysis of sustainability faces a number of formidable epistemological challenges. In fact, when studying the interface of socio-economic and ecological processes, we are dealing with two classes of processes requiring different dimensions and scales of analysis (Allen and Starr, 1988; Allen et al., 2003; Ewert et al. 2009; Giampietro, 2003). In other words, the issue of sustainability entails the need to provide policy makers with quantitative tools integrating biophysical, social and economic variables that provide characterisations of processes taking place simultaneously across different scales (at household level, community level, provincial level, national level and global level). This is the reason that led to the development of methodological approaches aimed at generating integrated quantitative characterisations across different dimensions and scales (Giampietro, 2003; Giampietro et al. 2012; Munda, 2008).

In this paper, I aim to present an application of the MuSIASEM approach (Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism) which is a method that has been developed exactly to deal with the technical conundrum associated with the issue of scaling (how to *"deal with the transfer of information between levels of the organization [including changes in the associated scales] not only within each dimensions but also between dimensions"*, [Ewert et al. 2011]). The method presented here refers only to the analysis of monetary flows, but the analysis presented in study is framed within a larger multi-disciplinary research that intends to characterise the metabolic pattern of urban areas in relation to both economic and biophysical flows (water metabolism). In this analysis it is essential to be able to move information gathered at different hierarchical levels: the consumption or production of the chosen flows in relation to the whole (the country, the province, the city) has to be linked to the consumption or production of the chosen flows in relation to the parts of the whole (regions of the country, towns in the province, areas of the city).

1.2 The analysis of the Gross Value Added

Generally, countries have a System of National Accounts (SNA) that allows them to elaborate an overall measurement of the economic activities carried out within a certain country in a given period of time. This SNA follows standard guidelines set up by the United Nations

Statistical Commission with a view to homogenizing accounting criteria[1]. The SNA classifies transactions that occur among economic actors, with the aim of estimating the production of a country's goods and services in one year. Normally, this information is then presented in economic tables containing the main macroeconomic indicators (Fuentes et al. 1995). The increasing demand for detailed statistical information at a sub-national level has given rise to a number of government agencies already submitting this information. For example, Spain includes, in some cases, statistical information up to NUTS Level 3[2].

One of these indicators is the Gross Value Added (GVA), which represents the value added generated in the production process. This macroeconomic indicator measures the value of production of all final goods and services produced minus intermediate consumption of goods used in that production, within a specific geographic area over a given period of time. GVA further groups economic actors in different homogeneous categories according to their economic activities. These categories are called economic sectors or productive branches. When we add import duties and taxes on products to GVA, we then obtain what is known as Gross Domestic Product (GDP), which is the best known macroeconomic indicator at an international level and that most widely used in order to assess the economic performance of countries.

If we want to study the sustainability of societies from the production and consumption sectors simultaneously across different hierarchical levels (at city level, province level, country level), then we have to estimate GVA at local levels, depending on the definition of the geographic area associated with the relevant parameters to study (for further information, see Giampietro et al. 2012). Although, traditionally GVA is an indicator applied to macro-regions or countries, in recent years the use of this indicator for geographic scales smaller than those previously mentioned has increased (Faramondi et al. 2004). In relation to this objective, in order to have the required information about GVA for economic entities defined at sub-national levels; it becomes necessary to estimate Gross Value Added per year at local scale in those cases where such information is not available.

The structure of the rest of this paper is as follows: Section 2 presents the approach and the methodology. Section 3 shows two cases of application: the province of Barcelona

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[1] See, for instance, http://unstats.un.org/unsd/nationalaccount/

[2] The Eurostat set the Nomenclature of Territorial Units for Statistics (NUTS) as a form of geocode standard by means of which each Member State is divided into a whole number of regions, NUTS 1, which in turn, is divided into NUTS 2 and so on. The regulation allows for a minimum population of 3 million people for NUTS 1, 800,000 people for NUTS 2, and 150,000 people for NUTS 3 (EUROSTAT, 2012).

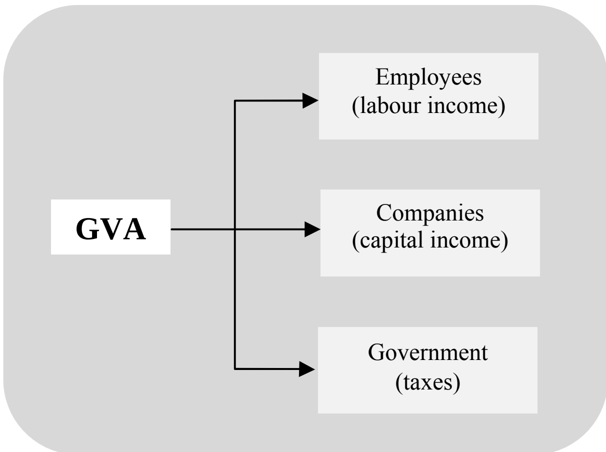
(Spain) and the region of Lima Metropolitan Area (Peru) –which includes the Constitutional Province of Callao and the Province of Lima. Finally, Section 4 discusses the reliability of the results and draws some conclusions.

2. Methodology

2.1 The application of the MuSIASEM approach to the analysis of GVA across levels

The composition of GVA in relation to different types of agents is shown in Figure 1. As illustrated in the figure there are three categories of economic agents associated with the generation of GVA: employees (workers), companies (entrepreneurs), and governments (local administrations).

Figure 1



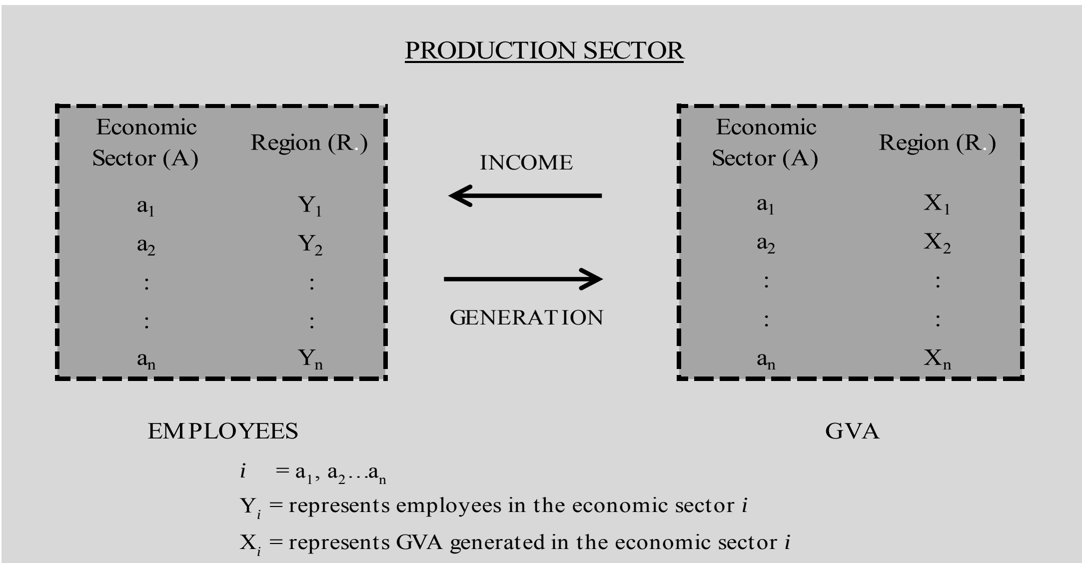
The MuSIASEM approach introduces a benchmark useful when extracting the economic performance of a country –the ELP (Economic Labour Productivity)– defined as the ratio of a given quantity of GVA (per year) divided by a given quantity of working hours (per year) defined for the same economic sector. Depending on the chosen scale of application, this quantity –ELP*i* (€/hour)– can be calculated in different ways. In order to characterise a sector of a given economy –e.g. the industrial sector– the ELP*i* becomes a sectorial benchmark (e.g. characterising the economic performance of Spain's industrial sector). In order to characterise the economic performance of a whole country –the economy of Spain– the benchmark becomes the ratio: GDP/hour worked of Spain (€/hour average per year).

The next step to understanding how to estimate GVA across levels is to study its components. We have mentioned in Figure 1 the economic agents, we now need to include the economic activities and the geographical and political boundaries of the economic entity. In fact the validity of this methodology depends on the homogeneity of the activities performed across economic sectors in terms of utilisation of production factors. For this reason, the analysis of this condition is one of the first steps that needs to be taken in this methodology. The estimate of GVA for economic entities defined at a smaller geographic scale requires homogeneity of the ELP value within each economic productive sector, that is, that a value of an intensive variable estimated at the level of the whole can be used as a benchmark valid also at a smaller scale.

2.2 The quantitative model

A different view of the assessment of GVA is provided in Figure 2 indicating the circular flow associated with this concept.

Figure 2



In this flow, GVA's generators are employees working in the Region (R) and in any of the economic sectors. In this perception, GVA is returned to them in the form of income.

Based on this flow we can define a given level of GVA per employed person per economic sector (Z_i). As shown below:

$$Z_i = \frac{X_i}{Y_i} \quad (1)$$

Where (Z_i) represents, in monetary terms, each employee's average productive contribution in the economic sector *i*. In other words, if the GVA of the economic sector *i* was distributed, this would be the part corresponding to each employee. If we assume that: (i) the mobility of employees between the different areas in a region is negligible; (ii) there is no significant difference in wages among the employees of the same branch of production; (iii) the technology used for production between different parts of the region is standard, then the labour performance remains constant 1) at any location within the region (R) and 2) the employee's technological capacity. According to the MuSIASEM scheme, ELP is established as a benchmark for the multi-scale estimation of GVA:

$$ELP_i = \frac{Z_i}{W_i} \quad (2)$$

Where:

ELP_i = defined as the ratio of a given quantity of GVA (per year) divided by a given quantity of working hours (per year) in the economic sector *i.*

W_i = represents the annual workload for each worker of sector *i* (e.g. 2000 hours of work per year)

Therefore, if we divide the region R in areas, in such a way that:

$$\mathrm{R} = r_1 + r_2 + \ldots\ldots r_m \quad (3)$$

Then:

$$GVA_R = GVA_{r_1} + GVA_{r_2} + \ldots\ldots GVA_{r_m} \quad (4)$$

Equation (3) means that each area of the region (R) has a production sector that: i) is held by employees, ii) is capable of generating GVA and iii) can group production activities in the same economic sectors of the region (R). As shown in Table 1.

Table 1

Economic Sectors	Region (R)			
	$\mathbf{r_1}$	$\mathbf{r_2}$	....	$\mathbf{r_m}$
$\mathbf{a_1}$	y_{11}	y_{12}	....	y_{1m}
$\mathbf{a_1}$	y_{21}	y_{22}	....	y_{2m}
:	:	:	....	:
:	:	:	....	:
$\mathbf{a_n}$	y_{n1}	y_{n2}	....	y_{nm}

Where:

$i = a_1, a_2, \ldots a_n$

$j = r_1, r_2, \ldots. r_m$

y_{ij} = represents employees of the economic sector *i* in the area *j*

Therefore, if we relate the global number of hours worked by the workers of the area *j* with its correspondent value of ELP, we obtain the GVA of the economic sector *i* for that area:

$$GVA_{ij} = ELP_i * W_{ij} * y_{ij} \qquad (5)$$

Finally, the GVA in the area *j* is:

$$GVA_j = \sum_i GVA_{i.} \qquad (6)$$

3. The empirical Test

3.1 Data used in the analysis

In the first case, Catalonia's GVA has been obtained from the National Statistics Institute of Spain (INE) (INE, 2012a). Hours worked in Catalonia correspond to paragraph Total Employment provided by the INE (INE, 2012b). To determine the hours worked in Barcelona, the hours worked in Catalonia were divided by the jobs belonging to its corresponding economic sector, this parameter was then multiplied by the number of jobs in section Total Jobs in Barcelona.

In the second case, GVA figures for the Region of Lima provided by the National Institute of Statistics of Peru (INEI) (INEI, 2011a) are used. GVA values for Lima Metropolitan Area will be the estimates produced by the Ministry of Labour and Employment Promotion of Peru (MTPE, 2008), which will serve as the monitoring tool. To determine the number of hours worked in the Region of Lima and in Lima Metropolitan Area, we used the average number of hours worked/week by economic sectors in Lima Metropolitan Area and multiplied it by the economically active population in each area (INEI, 2011b). Due to the significant differences in working conditions (formal and informal employment, hours of work, professional training, etc.) the economic activities were broken down into economic sectors and subsectors to improve the calculation of these variables. The interest in estimating the GVA of this area, Lima Metropolitan Area, rests on the fact that the results obtained will be used to develop a metabolic analysis of the role water plays in socio-economic development.

3.2 The province of Barcelona

In this first case, I test the model by estimating the GVA in Barcelona province (Level n-1) using a combination of top-down and bottom-up information. For this task I use the data available from the Autonomous Community of Catalonia (Level n) for the years 2001-2008. This province was selected given that the INE provides official estimates of GVA at the provincial level (INE, 2012a) and this makes it possible to compare the estimates obtained with our model of the value of the province, against the official assessment given by INE.

The published values of GVA as well as the number of hours worked in Catalonia are provided in Table 2. This information can be split into five economic sectors: i) agriculture, livestock and fisheries; ii) energy, iii) industry, iv) construction and v) services.

The value of GVA over the study period has grown in all sectors. The Service sector recorded the highest values of worked hours throughout all years: from 3.175 billion hours worked in 2001 to 4.008 billion hours worked in 2008. This represents an average annual growth rate of 3.39%. The construction sector also registered a growth that went from 567 million hours in 2001 to 668 million hours in 2008. That is, an average annual growth rate of 2.38%. On the contrary, in the agriculture, livestock and fisheries' sector, the number of hours worked fell from 174 million hours worked in 2001 to 152 million hours worked in 2008. This implied a 1.87% contraction in the annual average rate. Similarly, in the industry sector the number of hours worked fell from 1.325 billion hours in 2001 to 1.162 billion hours in 2008, thus presenting a contraction of 1.85% in the average annual growth rate. Meanwhile, in the energy sector the number of hours increased from 28 million hours in 2001 to 29 million hours in 2008, i.e., it registered an annual average growth rate of 0.49%.

The resulting values of ELP recorded an increase during 2002-2008, as shown in Table 2, probably as a result of the economic boom experienced over those years. The construction and energy sectors witnessed the highest growth rate with 8.57% and 7.71%, respectively. Using the estimation of the benchmarks for the ELPi of the different sectors we can finally calculate the GVA of the province of Barcelona using the model presented earlier on (Table 3). Our estimates of GVA are shown and compared against the official figures provided by INE. As shown in Figure 3, the difference between the two values is very small (less than 1% across all years). In this case, we have an example in which the homogeneity of productive and remunerative factors across the two economic entities subject to study (the province of Barcelona and Catalonia as a whole) is very high. As a matter of fact, the province of Barcelona, economically speaking, represents the bulk of the Catalan economy. Overall, if we compare the number of hours worked in 2008 between Catalonia (6.019 billion hours) and Barcelona (4.427 billion hours), we can see that 74% of the labour activity of the Autonomous Community is produced in Barcelona.

Table 2

CATALONIA (level n)

GVA Current prices (in millions €)

Economic sectors	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007 (P)**	**2008 (P)**
Agriculture, livestock and fisheries	2373	2444	2576	2540	2498	2461	2599	2571
Energy	2388	2432	2614	2853	3094	3328	3542	4157
Industry	29284	29593	30275	31227	32311	33850	35096	35575
Construction	8828	9968	11260	12970	14949	17142	18274	18501
Services	73973	80125	86261	92731	99370	107424	117312	124732
Total	**116845**	**124563**	**132985**	**142321**	**152222**	**164205**	**176822**	**185536**

Worked hours per sectors (in millions)

Economic sectors	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007 (P)**	**2008 (P)**
Agriculture, livestock and fisheries	174	177	178	171	179	180	162	152
Energy	28	26	27	29	27	27	29	29
Industry	1325	1293	1273	1256	1232	1213	1181	1162
Construction	567	583	597	627	638	705	735	668
Services	3175	3257	3380	3499	3661	3804	3901	4008
Total	**5268**	**5336**	**5453**	**5584**	**5736**	**5929**	**6007**	**6019**

ELP per sectors (€/hour)

Economic sectors	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Agriculture, livestock and fisheries	13.63	13.83	14.50	14.83	13.99	13.65	16.07	16.86
Energy	86.67	93.63	98.31	97.06	114.87	123.33	121.67	145.75
Industry	22.11	22.89	23.79	24.85	26.23	27.92	29.72	30.61
Construction	15.58	17.10	18.88	20.67	23.43	24.32	24.88	27.69
Services	23.30	24.60	25.52	26.50	27.15	28.24	30.08	31.12

(P) Preliminary data. (Source: IDESCAT, 2012; INE, 2012a; INE, 2012b)

Table 3

BARCELONA (level n-1)

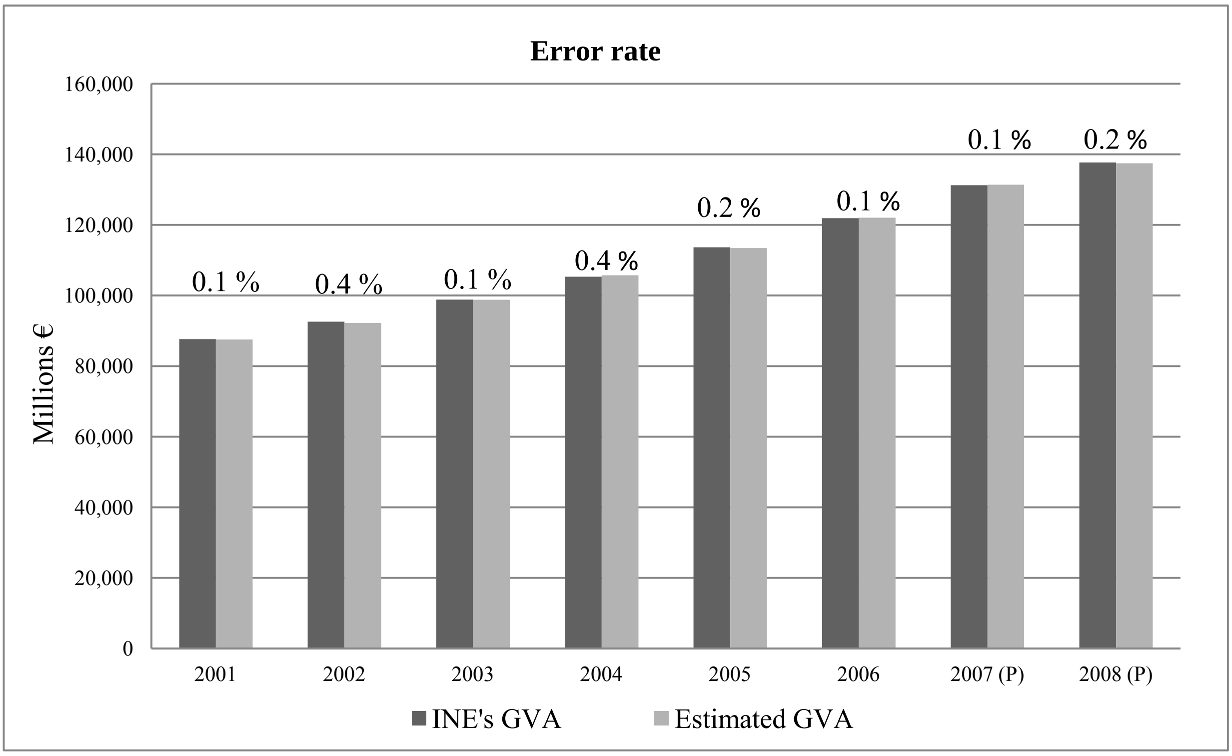
Worked hours per sectors (in millions)

Economic sectors	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007 (P)**	**2008 (P)**
Agriculture, livestock and fisheries	52	55	53	52	57	62	51	49
Energy	20	19	19	22	19	19	21	21
Industry	1070	1032	1017	998	979	963	932	912
Construction	362	375	385	410	410	454	466	436
Services	2396	2426	2533	2624	2768	2865	2952	3010
Total	**3900**	**3907**	**4008**	**4106**	**4234**	**4364**	**4422**	**4427**

GVA Estimated (in millions €)

Economic sectors	**2001**	**2002**	**2003**	**2004**	**2005**	**2,006**	**2007 (P)**	**2008 (P)**
Agriculture, livestock and fisheries	711	755	769	774	795	847	814	827
Energy	1739	1763	1894	2117	2198	2349	2507	2990
Industry	23659	23622	24196	24807	25687	26882	27710	27918
Construction	5643	6412	7270	8471	9614	11041	11586	12065
Services	55815	59685	64650	69553	75135	80918	88797	93665
Estimated GVA	**87567**	**92237**	**98779**	**105721**	**113428**	**122037**	**131415**	**137466**
GVA's INE	**87659**	**92606**	**98836**	**105344**	**113665**	**121938**	**131238**	**137700**

Figure 3. Comparison between estimated GVA and actual values of GVA



3.3 The region of Lima Metropolitan Area

In this second case, the study focuses on the multi-scale assessment across two levels: (i) the region of Lima (level n) and (ii) the Lima Metropolitan Area (level n-1). The Lima Metropolitan Area (this includes the Constitutional Province of Callao and the Province of Lima) is located in the central-western part of the country. At a political-economic sphere this is the most important region in Peru given that it is where the Government and Ministries are headquartered. This area is home to 30% of the national population and produces about half of the national GDP.

Table 4 presents GVA values for the Region of Lima. This information is split into six sectors i) agriculture, ii) fisheries, iii) mining, iv) manufacturing, v) construction and vi) total services. The latter is in turn divided into four subsectors a) trade, b) transport and communications, c) restaurants and hotels and d) services. It can be seen that the total services sector was, during 2001-2008 the one that registered the highest division in GVA. In this period, the total services sector increased the total number of hours worked for 6.704 billion hours in 2001, to 8.077 billion hours in 2008. This represents an average annual growth rate of 2.70%. However, the sector that registered a higher annual growth rate was mining, i.e. 16.56%. This was because in 2001 the number of hours worked was estimated at 24 million hours, whilst in 2008 the figure was estimated at 70 million hours worked. Practically, this variable tripled in a span of 8 years. Instead, for the period 2001-2008, the fishing and agricultural sectors were those that presented a contraction in the average annual growth rate of 4.38% and 0.23% respectively. This was due to the fact that the number of hours worked in the fishing industry declined from 32 million hours in 2001 to 23 million hours in 2008. Meanwhile, the agricultural sector equally registered a decline from 389 million hours in 2001 to 383 million hours in 2008.

ELP values have also increased in almost all sectors for the period 2001-2008. In particular, in the fishing sector and the trade subsector, registering an annual growth rate of 13.67% and 7.42% for said period. In the case of mining, the sharp fluctuation in hours worked in the early years of the period under study may be due to i) an error when estimating the number of people working in this sector, ii) an increase jobs in the informal sector or iii) a combination of both. It is worth pointing out that, in recent years, the economy of Peru and that of Lima Metropolitan Area has shown significant economic growth primarily driven by mining. The reason behind this economic boom is mainly due to the increase in the international prices of commodities, particularly that of copper, of which Peru is the second largest global producer (Berganza, 2009; Isasi, 2008). The mining boom that has been experienced in recent years is reflected in the acquisition workforce, which is reflected in the number of hours worked in this sector. In 2001, the region of Lima recorded 24 million hours worked, while in 2008, this figure tripled to 70 million hours worked (see Table 4). This represents an annual growth of 16.56%.

We believe that the use of the ELP as a benchmark to estimate Lima’s GVA (level n-1), from the Region of Lima (level n), is a reliable strategy given that approximately 91% of the economically active population is located in this area. However, care must be taken in light of the enormous heterogeneity in the economic sectors.

Via the use of the estimates provided by the benchmarks for the ELP of the different sectors we can finally calculate Lima Metropolitan Area’s GVA using the model presented earlier (see Table 6). Our estimates of GVA are shown and compared against the official figure provided by the MTPE. Figure 4 shows that the error rate varies between 10% and 11% in the period spanning from 2001 to 2006. However, we believe that the projections made by the MTPE are overestimated. This statement is based on the fact that they even exceed the GVA estimates made by the INEI for the region of Lima. However, our GVA estimate in 2007 is quite close to that provided by the MTPE, allowing for an error rate of 3.6%.

Table 4

THE REGION OF LIMA

GVA Basic prices of 1994 (in millions Nuevos Soles)

Economic Sectors	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture	2215	2301	2325	2375	2513	2698	2815	3151
Fisheries	95	95	64	119	120	150	161	170
Mining	668	695	757	821	872	916	807	848
Manufacturing	10063	10559	10925	11714	12686	13609	15444	17051
Construction	3014	3130	3242	3220	3480	3763	4245	4742
Total Services	40195	41630	43228	45391	48373	53023	58558	65006
Trade	10076	10432	10671	11572	12365	14238	15809	18398
Communications and transporting	5466	5636	5937	6344	6907	7811	9369	10392
Restaurants and hotels	3029	3116	3253	3399	3582	3766	4108	4550
Services	21624	22445	23366	24076	25520	27208	29272	31666
Total	**56250**	**58410**	**60541**	**63640**	**68043**	**74159**	**82029**	**90969**

Worked hours per sectors (in millions)

Economic Sectors	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture	389	438	518	568	460	508	416	383
Fisheries	32	29	60	22	30	32	32	23
Mining	24	10	10	45	40	53	53	70
Manufacturing	1361	1312	1351	1575	1580	1619	1854	1910
Construction	381	448	579	572	471	585	616	646
Total Services	6704	6744	7494	7448	7513	7652	7905	8077
Trade	2223	2183	2480	2440	2423	2453	2401	2459
Communications and transporting	862	891	1043	1022	1132	1171	1181	1422
Restaurants and hotels	589	676	716	718	673	671	664	727
Services	3030	2994	3254	3268	3285	3357	3659	3469
Total	**8891**	**8979**	**10012**	**10229**	**10093**	**10449**	**10876**	**11109**

Source: INEI, 2007, 2010, 2011a; 2011b

Table 5

ELP per sectors (Nuevos soles/hour)

Economic sectors	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture	5.69	5.25	4.49	4.18	5.46	5.31	6.77	8.23
Fisheries	3.00	3.31	1.08	5.36	4.01	4.74	5.02	7.35
Mining	28.06	73.01	75.92	18.42	21.80	17.31	15.14	12.18
Manufacturing	7.39	8.05	8.08	7.44	8.03	8.41	8.33	8.93
Construction	7.91	6.99	5.60	5.63	7.39	6.43	6.89	7.34
Trade	4.53	4.78	4.30	4.74	5.10	5.80	6.58	7.48
Communications and transporting	6.34	6.33	5.69	6.21	6.10	6.67	7.93	7.31
Restaurants and hotels	5.14	4.61	4.54	4.74	5.32	5.61	6.19	6.26
Services	7.14	7.50	7.18	7.37	7.77	8.11	8.00	9.13

Figure 4

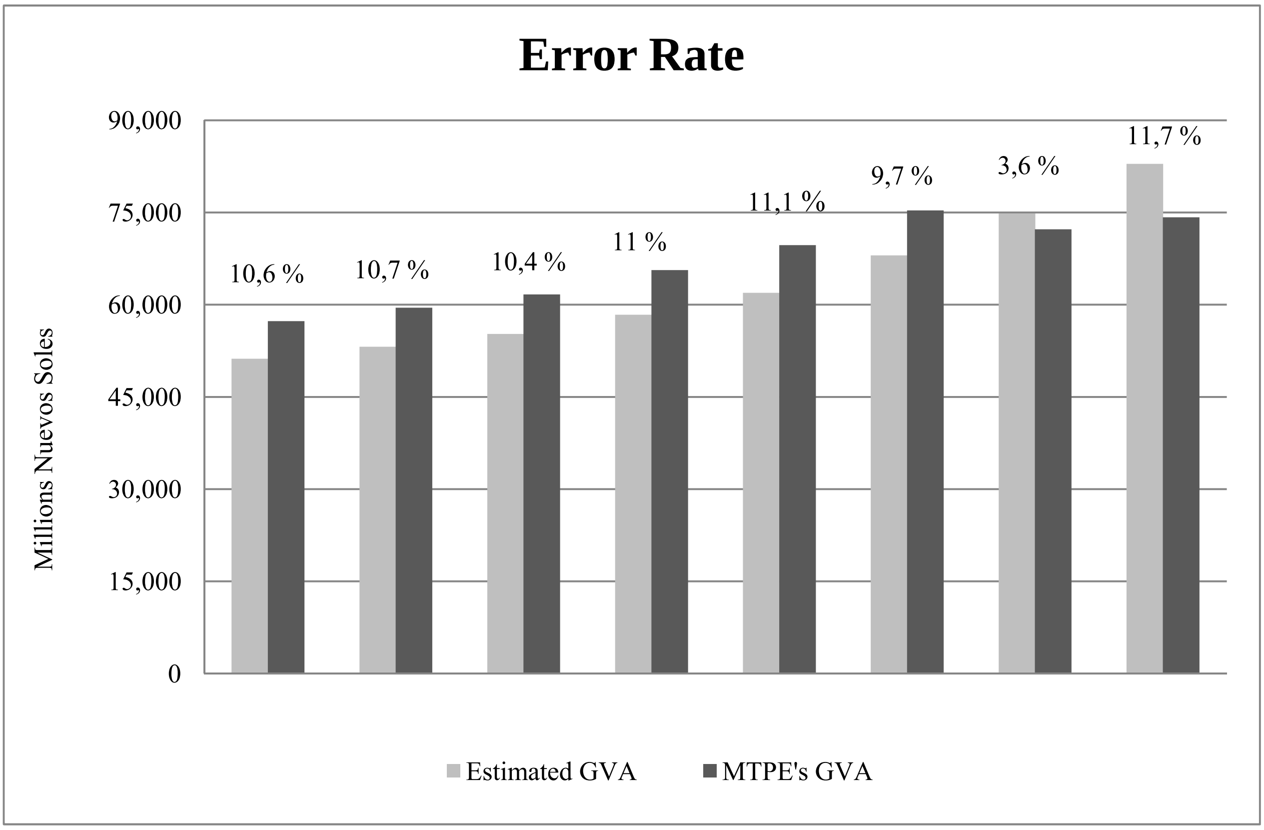


Table 6

LIMA METROPOLITANA

Worked hours per sectors (in millions)

Economic sectors	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Agriculture	52	41	93	102	94	88	92	72
Fisheries	9	17	36	9	20	17	16	12
Mining	26	12	8	47	41	57	53	54
Manufacturing	1287	1263	1297	1507	1502	1550	1775	1807
Construction	348	423	560	547	428	567	564	616
Total Services	6304	6292	7012	7007	7006	7180	7367	7562
Trade	2050	2023	2299	2292	2217	2269	2195	2274
Communications and transporting	819	828	982	961	1044	1088	1117	1336
Restaurants and hotels	547	630	647	665	634	635	595	667
Services	2888	2812	3084	3088	3111	3187	3460	3285
Total	**8026**	**8049**	**9005**	**9217**	**9090**	**9458**	**9866**	**10122**

GVA Estimated (in millions Nuevos Soles)

Economic sectors	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Agriculture	294	216	417	427	514	466	625	590
Fisheries	26	58	39	47	81	83	78	85
Mining	720	873	601	859	884	984	799	660
Manufacturing	9512	10167	10482	11210	12059	13025	14783	16125
Construction	2757	2958	3137	3076	3162	3647	3886	4519
Trade	9289	9664	9892	10869	11316	13169	14452	17012
Communications and trans	5193	5239	5589	5968	6370	7257	8861	9761
Restaurants and hotels	2814	2906	2938	3152	3373	3564	3682	4177
Services	20617	21077	22144	22751	24168	25834	27679	29991
GVA Estimated	**51222**	**53156**	**55238**	**58357**	**61928**	**68029**	**74846**	**82920**
MTPE's GVA	**57322**	**59525**	**61662**	**65631**	**69676**	**75338**	**72274**	**74221**

4. Discussion and conclusion

The main objective of this study is to find a simple and reliable method to estimate GVA for economic entities defined at sub-national level (level n-1), when the information and resources used to make a more detailed study are limited. The importance of estimating GVA values this way is crucial when adopting the MuSIASEM approach, since it becomes possible to associate, at different hierarchical levels, GVA flow with other types of flows (water flows, energy flows, waste flows) in an integrated analysis of the metabolic pattern of a socio-economic system across scales –country, different regions, individual cities, residential areas (within urban areas) or household typologies–. In practical terms, this method generates an indicator which is a more refined version of GDP's intensive variable per capita (for further information on this point, see Chapter 3 of Giampietro et al. 2012). The risk of using per capita GDP as a benchmark lies on the fact that a country's monetary value is supposed to be equally distributed among all its inhabitants, both in relation to geographic areas and social groups. This is obviously false; if this were the case then all persons living in the same country would receive the same salary, including the economically inactive population. The adoption of the indicator ELP*i* determining a value of generation of GVA per hour of paid work in different economic sectors makes it possible to develop more articulated analysis, which can later be coupled with biophysical analysis of material and energy flows associated with the different local economic processes.

Although the level of disaggregation of the economic sectors included in the proposed methodology does not seem to be relevant, results seem to indicate that changes in the configuration of those sectors can affect economic factors, and thus also affect the homogeneity of these over a period of time and to more or less extensive geographic scales. To provide an example, the significance of any sector within the total may vary (for instance, the mining sector in Lima) or changes in labour specialization can cause different compositions in productivity and work as a production factor. Another factor that may affect the homogeneity within sectors is the share of underground economy that exists in the sector, given that there is a significant difference between the incomes of formal and informal workers. For example, this will affect benchmarks such as ELP.

The main disadvantage in this procedure is that every time the system under analysis expresses strong heterogeneity in the pace or density of economic flows across geographical areas. Then this calls for the addition of new categories of analysis required to use intensive variables derived from top-down information (the benchmarks of a given sector) to estimate extensive variables (the amount of GVA for a given economic entity) defined at local scale. The next step of this study will be to apply the same procedure to the assessment of metabolic pattern of water across different scales to check the robustness of the basic conceptual approach.

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6. Bibliographic references

Allen T.F.H. & Starr T.B. (1988). Hierarchy: Perspectives for Ecological Complexity. University of Chicago Press.

Allen T.F.H., Giampietro, M. & Little, A.M. (2003). Distinguishing ecological engineering from environmental engineering. Ecological Engineering 20: 389-407.

Berganza, J. C., Gallego, S., Molina, L. & Serena J. Ma. (2009). Auge y caída del precio de las materias primas. Implicaciones para América Latina. *Banco de España*, *Boletín Económico, 9* 106−121. Available at: <http://www.bde.es/webbde/SES/Secciones/Publicaciones/InformesBoletinesRevistas/BoletinEconomico/09/Mar/Ficheros/art8.pdf> Reviewed on 10/06/2012.

Congreso de la República del Perú. (2006). Documento de Trabajo. Ley General del Trabajo. Available at: <http://www.congreso.gob.pe/comisiones/2006/trabajo/ley-general/texto.pdf>. Reviewed on 04/05/2012.

EUROSTAT (2012). NUTS – Nomenclature of territorial units for statistics. Available at <http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction>. Reviewed on 04/07/2012.

Ewert, F. van Ittersum M.K., Bezlepkina I., Therond O., Andersen E., Belhouchette H., Bockstaller C., Brouwer F., Heckelei T., Janssen S., Knapen R., Kuiper M., Louhichi K., Olsson J.A., Turpin N., Wery J., Wien J.E., Wolf J, (2009). A methodology for enhanced flexibility of integrated assessment in agriculture. Environmental Science & Policy, Volume 12, Issue 5, Pages 546-561.

Ewert F., van Ittersum M.K., Heckelei T., Therond O., Bezlepkina I., Andersen E. (2011). Scale changes and model linking methods for integrated assessment of agri-environmental systems Agriculture Ecosystems and Environment 142: 6-17

Faramondi, A., Foschi, F., Pascarella, C., & Puggioni, A. (2004). Local Area Macroeconomic Aggregates Estimation. In *Proceedings of European Conference on Quality and Methodology in Official Statistics* (Q2004), (pp. 232-233). Mainz, Germany: Federal Statistical Office Germany.

Fuentes, R., & Hidalgo, M. (Coord.), (1995). *Problemas de Economía Aplicada.* Pirámide: Madrid.

Giampietro, M. (2003). Multi-Scale Integrated Analysis of Agro-ecosystems. Boca Raton, FL:CRC Press.

Giampietro, M., Mayumi, K., & Sorman, A. H. (2012). *The Metabolic pattern of societes: where economists fall short*. Amsterdam: Routledge.

Institut de Estadistica de Catalunya –IDESCAT–. (2012). Anuario estadístico de Cataluña. Available at: <http://www.idescat.cat/pub/?id=aec&t=2008&lang=es> Reviewed on 30/03/2012.

Instituto Nacional de Estadística –INE–. (2012a). Cuentas Económicas. Contabilidad Regional de España. Base 2000. Available at: < http://www.ine.es/daco/daco42/cre00/dacocre.htm> Reviewed on 04/05/2012.

Instituto Nacional de Estadística –INE–. (2012b). Cuentas Económicas. Contabilidad Regional de España. Available at: <http://www.ine.es/jaxi/menu.do?L=0&type=pcaxis&path=%2Ft35/p010&file=inebase> Reviewed on 04/05/2012.

Instituto Nacional de Estadística e Informática –INEI–. (2007). XI Censo de Población y VI de Vivienda 2007. Available at: <http://desa.inei.gob.pe/censos2007/tabulados/?id=ResultadosCensales> Reviewed on 20/03/2012.

Instituto Nacional de Estadística e Informática –INEI–. (2010). Perú: Evolución de los indicadores de Empleo e Ingresos por Departamentos, 2001-2019. Available at: < http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib0936/libro.pdf> Reviewed on 21/03/2012.

Instituto Nacional de Estadística e Informática –INEI–. (2011a).Producto Bruto Interno por Departamentos 2001-2010. Año base 1994. Available at: <http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib0995/Libro.pdf> Reviewed on 21/03/2012.

Instituto Nacional de Estadística e Informática –INEI–. (2011b). Perú: Evolución de los indicadores de Empleo e Ingresos por Departamentos, 2001-2010. Available at: <http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib1005/Libro.pdf> Reviewed on 21/03/2012.

Isasi, F. (2008). Exposición: Minería en el Perú. Ministerio de Energía y Minas. Available at: <http://www.minem.gob.pe/minem/archivos/file/institucional/publicaciones/presentaciones/exposicion_minas_espa.pdf> Reviewed on 12/06/2012.

Ministerio de Trabajo y Promoción del Empleo –MTPE–. (2008). Uso del tiempo e inequidades de género en el trabajo remunerado y doméstico en Lima Metropolitana. *Boletín de Economía Laboral 40*, 68–69. Available at: http://www. mintra.gob.pe /archivos/file/estadisticas/peel/bel/BEL_40.pdf Reviewed on 12/06/2012.

Munda, G. (2008). Social Multi-Criteria Evaluation for a Sustainable Economy. Springer.